Long-Term Potential for Energy Efficiency in California Buildings and Industry

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Background

- **The use of electricity and natural gas by California's commercial, residential, and manufacturing sectors accounts for a significant fraction of the state's energy demand and greenhouse gas (GHG) emissions**

Sector	Estimates for 2004					
	Electricity Use		Natural Gas Use		GHG Emissions (due to electricity and natural gas use)	
	GWh	% of CA Total	MTh	% of CA Total	MMTCO2e	% of CA Gross Emissions
Residential buildings	84,794	31%	5,150	21%	67	14%
Commercial buildings	99,362	37%	1,960	8%	57	12%
Manufacturing	44,061	16%	3,145	13%	46	9%
Total (above 3 sectors)	**228,217**	**84%**	**10,255**	**42%**	**170**	**35%**
Total for all of CA sectors	271,994		24,200		484	

Sources: California Energy Consumption Database (http://www.ecdms.energy.ca.gov/), U.S. DOE EIA Natural Gas Navigator, and California Air Resource Board, Greenhouse Gas Inventory Data - 1990 to 2004 (http://www.arb.ca.gov/cc/inventory/data/data.htm).

- **Energy efficiency improvements to California buildings and industrial facilities are critical toward reducing state energy demand and achieving the GHG reduction goals of Executive Order S-3-05**

Project goals

- **To develop an analytical framework for estimating the potential electricity and natural gas savings associated with efficiency improvements in California's industrial, residential and commercial sectors over the long-term (i.e., through 2050) that considers:**
  - **Structural changes in California (e.g., changes to housing stock and industrial output)**
  - **End use technology changes (e.g., efficiency improvements)**
  - **Changes in end use service demand**
  - **Future technology and energy costs**

- **To provide results that can serve as useful inputs to other state energy and econometric models for policy evaluation (e.g., energy efficiency supply curves)**

- **Primary challenge was to strike a balance between modeling detail, available resources, and inherent (and significant) uncertainties associated with long-term projections**
  - **Focus on key end uses**
  - **Cumulative changes (2025 and 2050) versus year-by-year granularity**

Modeling approach

- **Research team developed a hybrid modeling approach that coupled bottom-up, technology rich end-use models for the mid-term analysis period (2007-2025) with more aggregate and stylistic models of end-use efficiency for the long-term analysis period (2026-2025)**
  - Mid-term analyses designed to leverage the technology-rich, short-run potential estimates recently developed by Itron (buildings) and LBNL (industry) for the California IOUs
  - Long-term analyses employ more exploratory, prototype representations of future energy efficiency technologies

- **Modeling scope limited to technical potential of "in-paradigm" technologies**
  - Theoretical benchmark of the upper bound of energy efficiency potential in a technical feasibility sense, regardless of cost or acceptability to customers
  - No attempt to capture potential savings from completely new end-use technology paradigms

- **Parallel modeling of the residential and commercial sectors (Itron) and the industrial sector (LBNL/Ecofys)**

Modeling detail: buildings

Sector	Residential	Commercial
Geographic region	• 16 standards climate zones	• Statewide
Building type	• Single-family dwelling • Multi-family dwelling	• College • Food Store • Health • Large Office • Lodging • Miscellaneous • Refrigerated Warehouse • Restaurant • Retail • School • Small Office • Unrefrigerated Warehouse
Building vintage	• Existing construction • New construction	• Existing construction • New construction
End use	• Space Cooling • Space Heating • Furnace Fan • Water Heating • Cooking • Refrigerator • Freezer • Clothes Dryer • Lighting • Pool Pump • Miscellaneous	• Space Cooling • Space Heating • Ventilation • Water Heating • Commercial Cooking • Refrigeration • Exterior Lighting • Interior Lighting • Office Equipment • Miscellaneous

Modeling detail: industrial

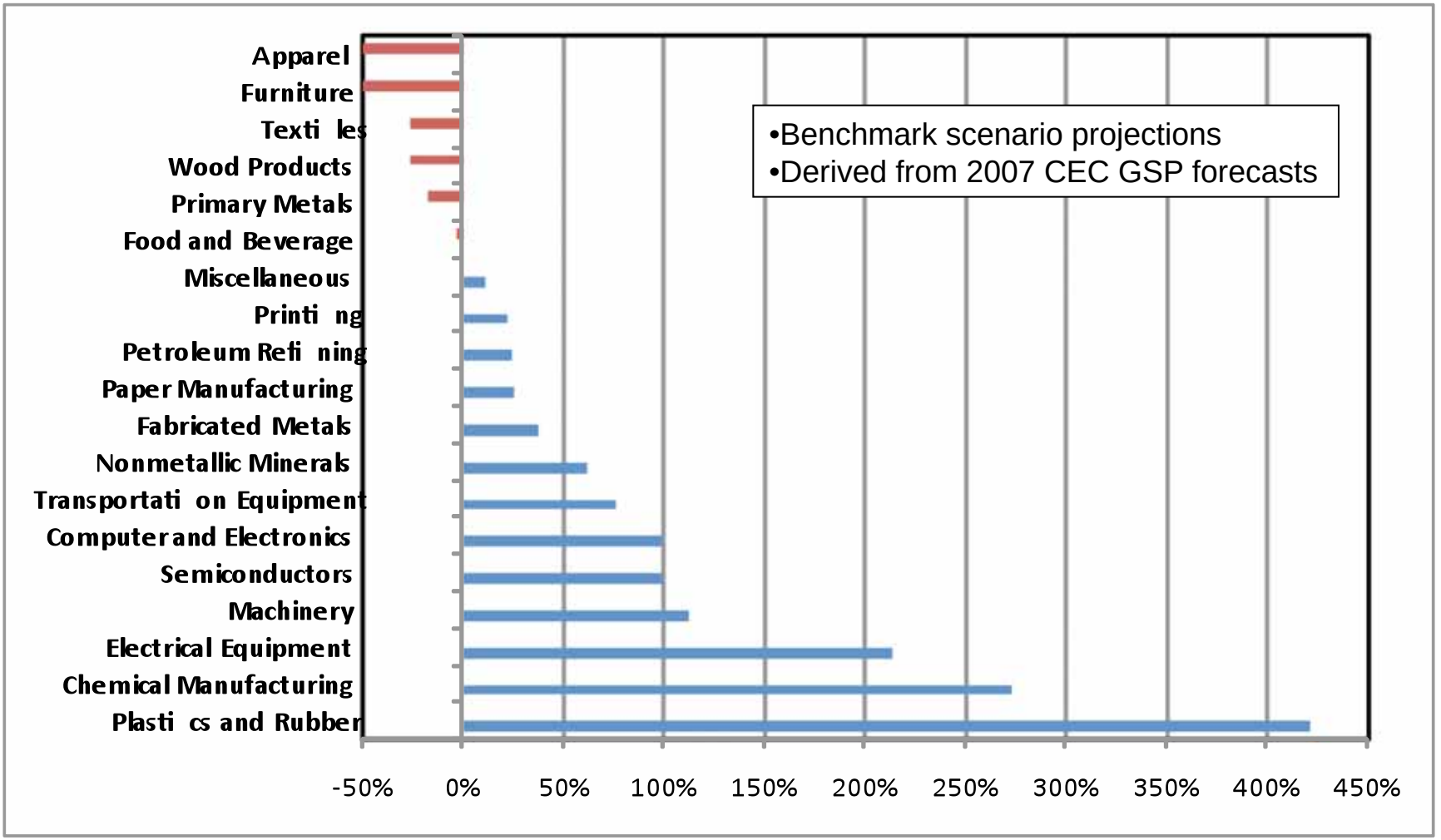
Focus on end uses of greatest significance in California:

- **Modeling of cross cutting technologies for all industrial sub-sectors:**
  - — Electricity (82% of total use)
    - Motors (52%)
      - Drives (19%)
      - Pumps (18%)
      - Compressed air (9%)
      - Fans (8%)
    - HVAC (12%)
    - Refrigeration (9%)
    - Lighting (8%)
  - —Natural gas (48% of total use)
    - Steam systems (26%)
    - CHP (10%)
    - HVAC (8%)

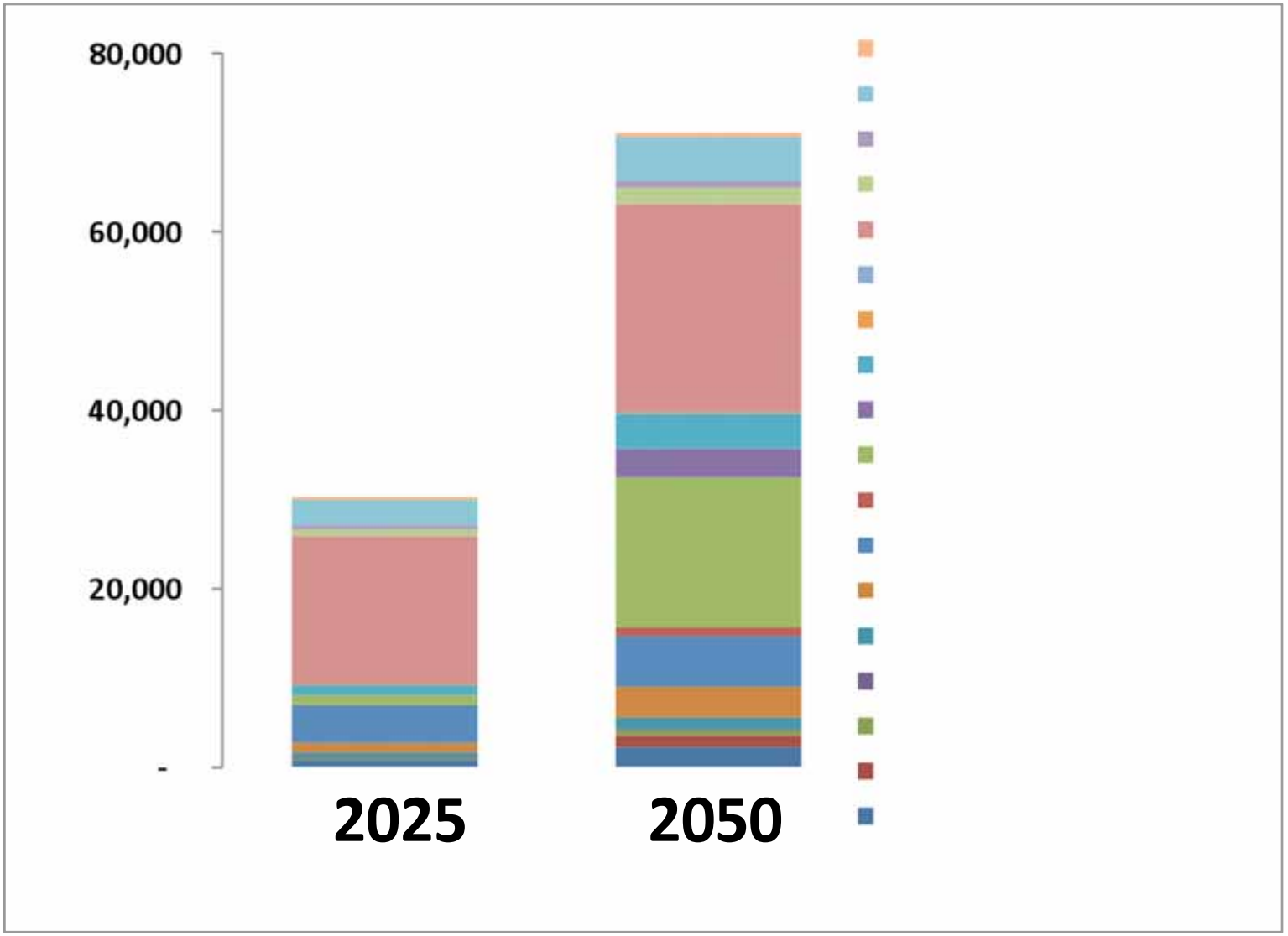
- **Modeling of process heating technologies for the most important industrial sub-sectors:**
  - — Electricity (9% of total use) (food, refineries, plastics, glass, metals, electronics)
  - — Natural gas (48% of total use) (food, refineries, chemicals, cement, glass, metals)

Long-term structural change: Industry

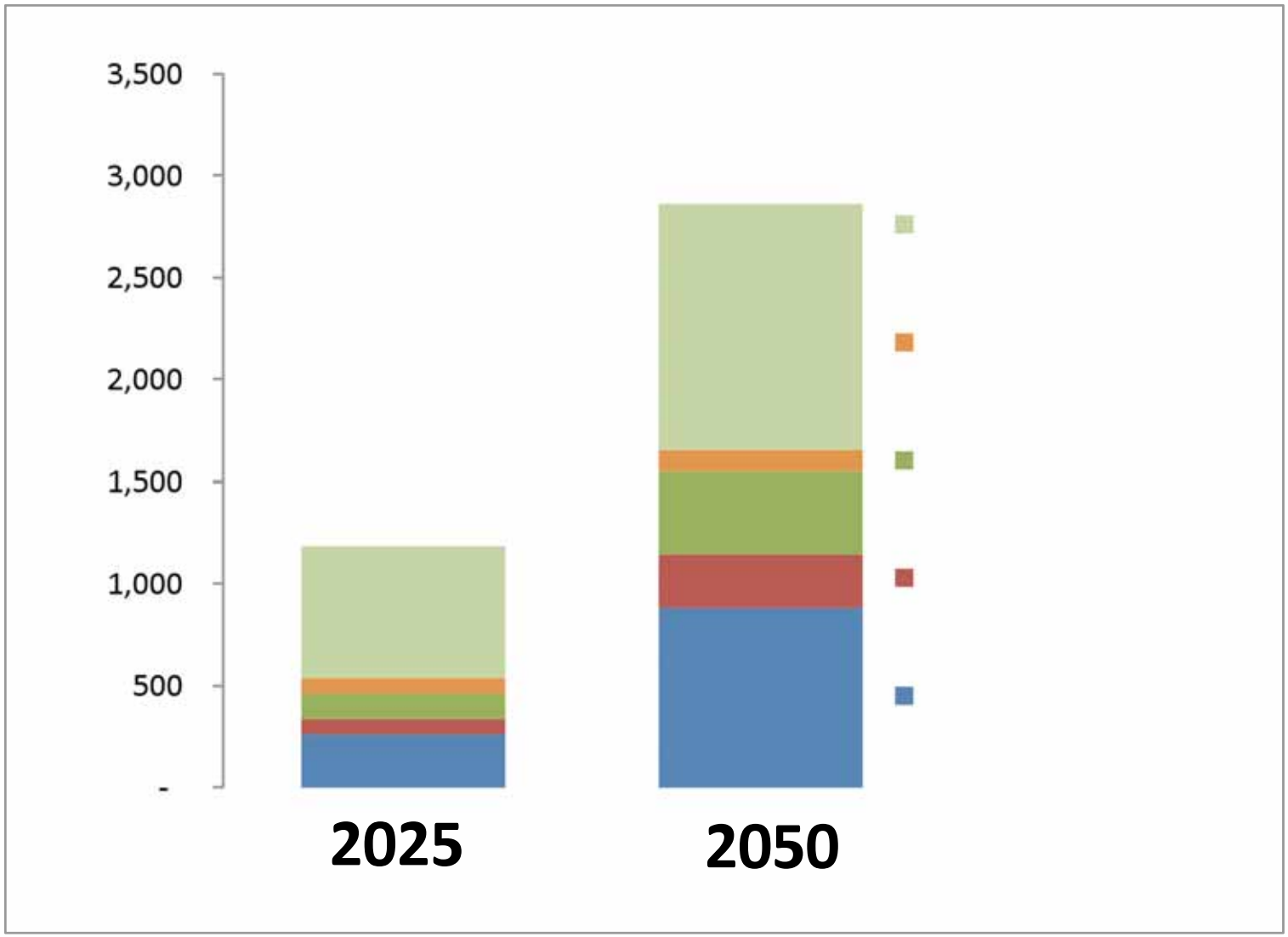
% Change in CA Industrial Sub-sector Output (GSP) 2006 – 2050



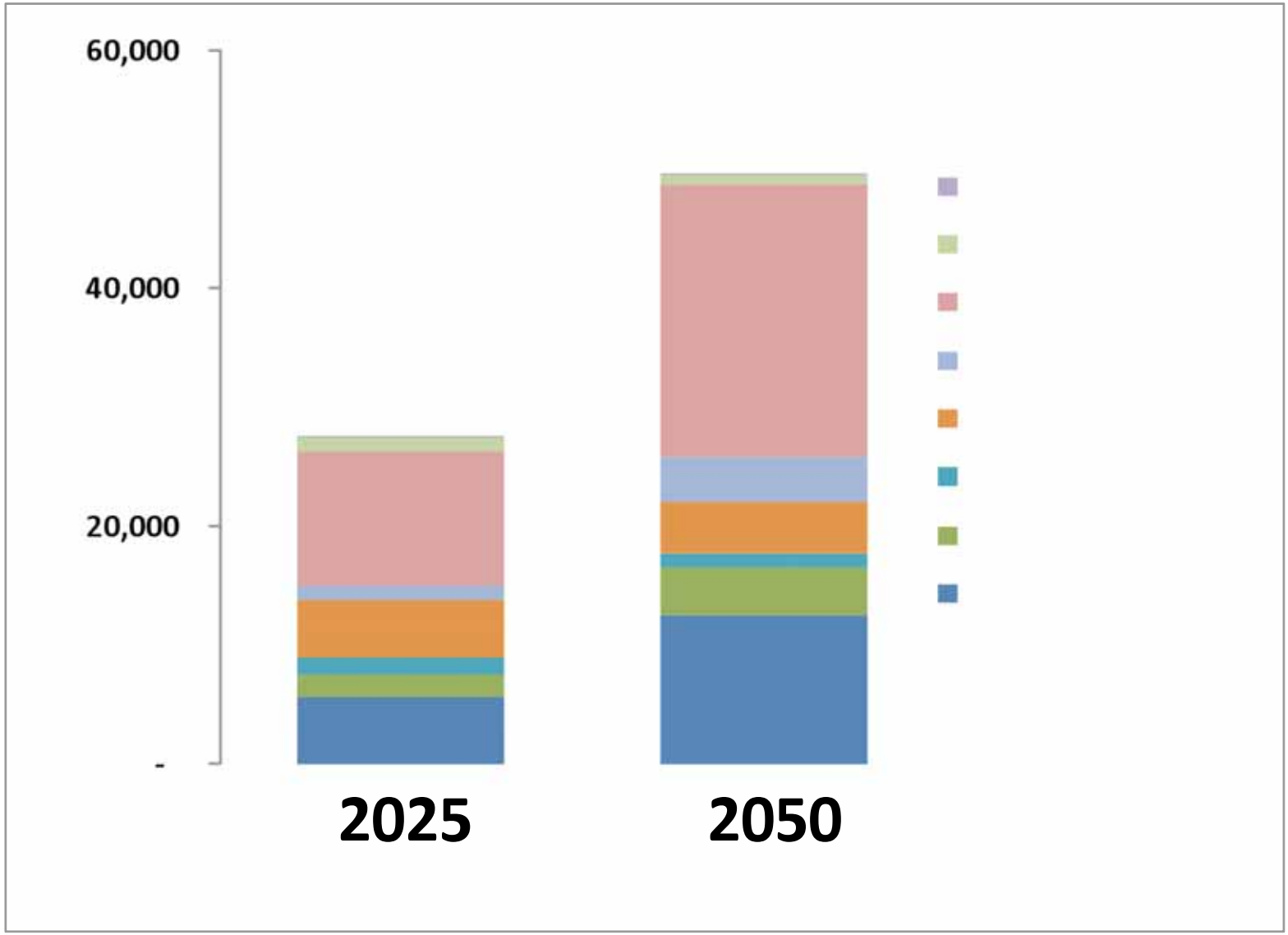
2050 Residential Electricity Potentials



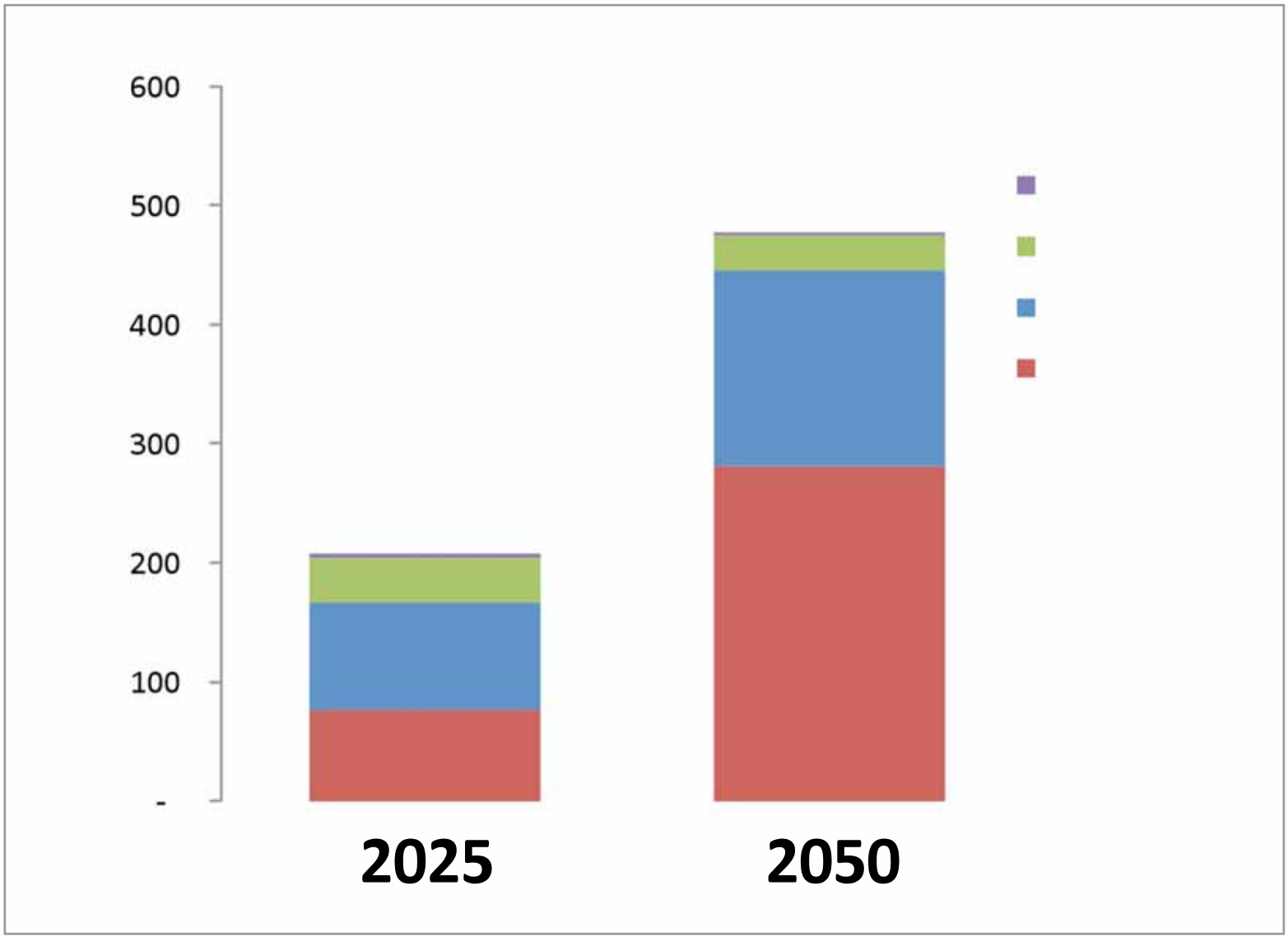
2050 Residential Gas Potentials



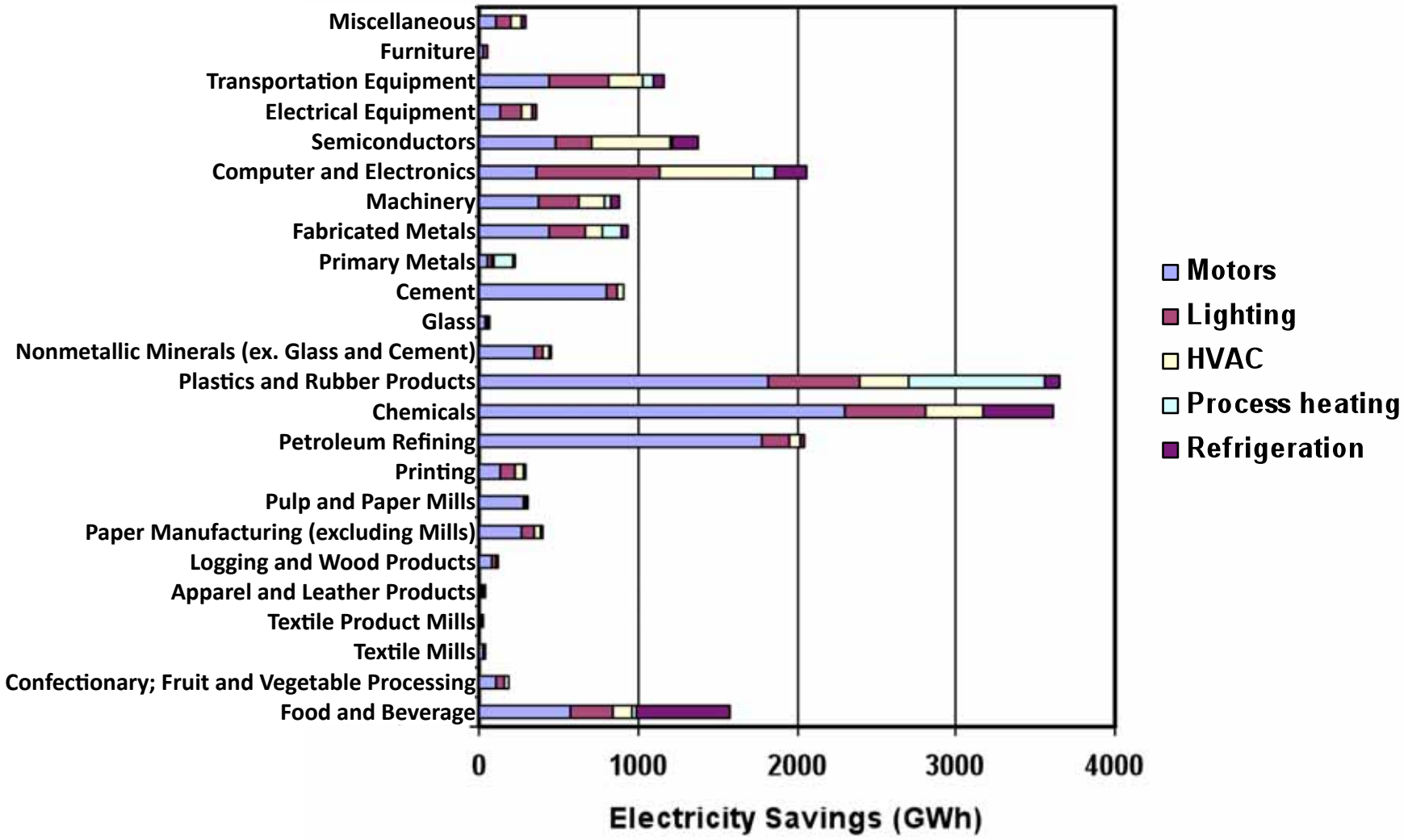
2050 Commercial Electricity Potentials



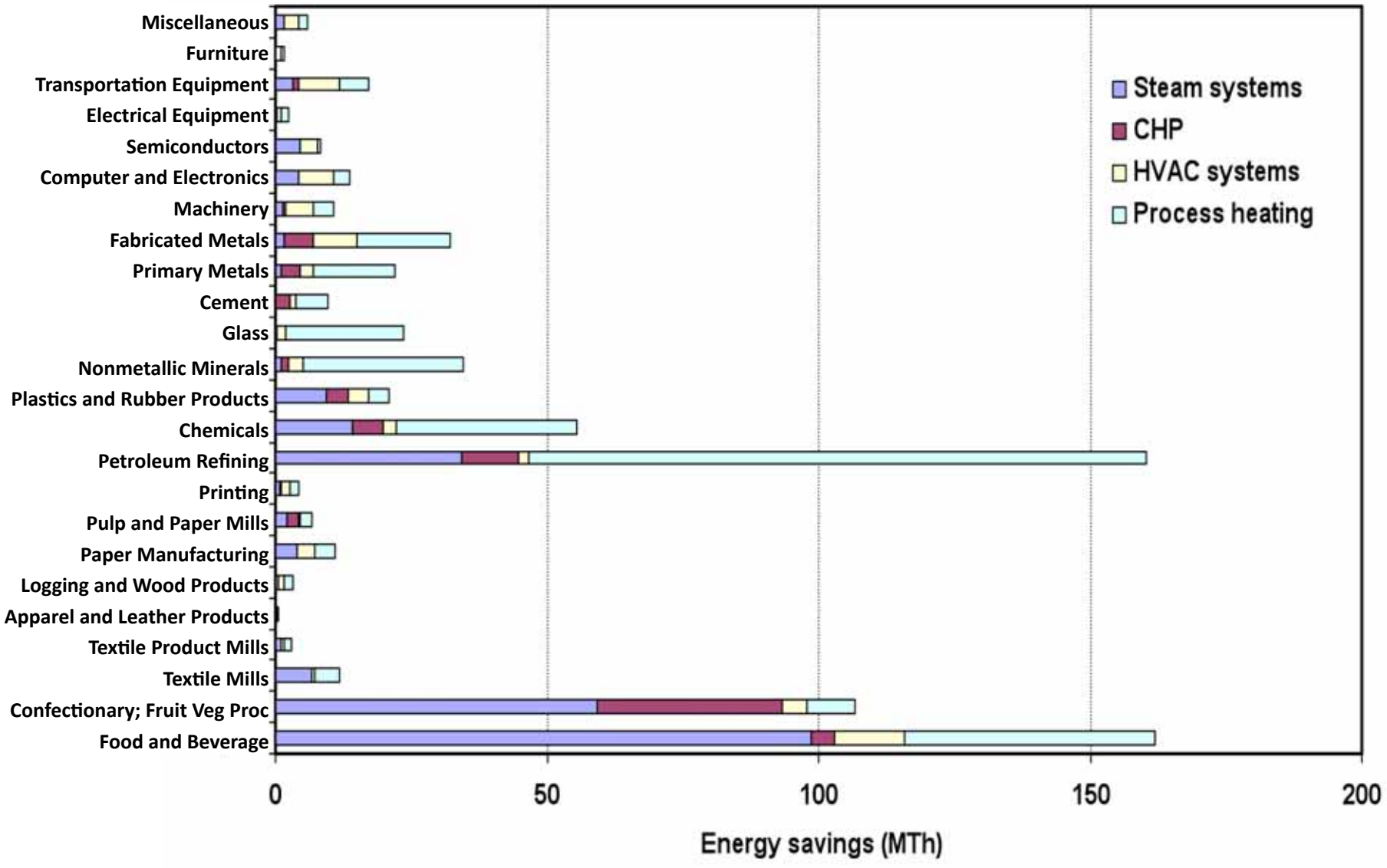
2050 Commercial Gas Potentials



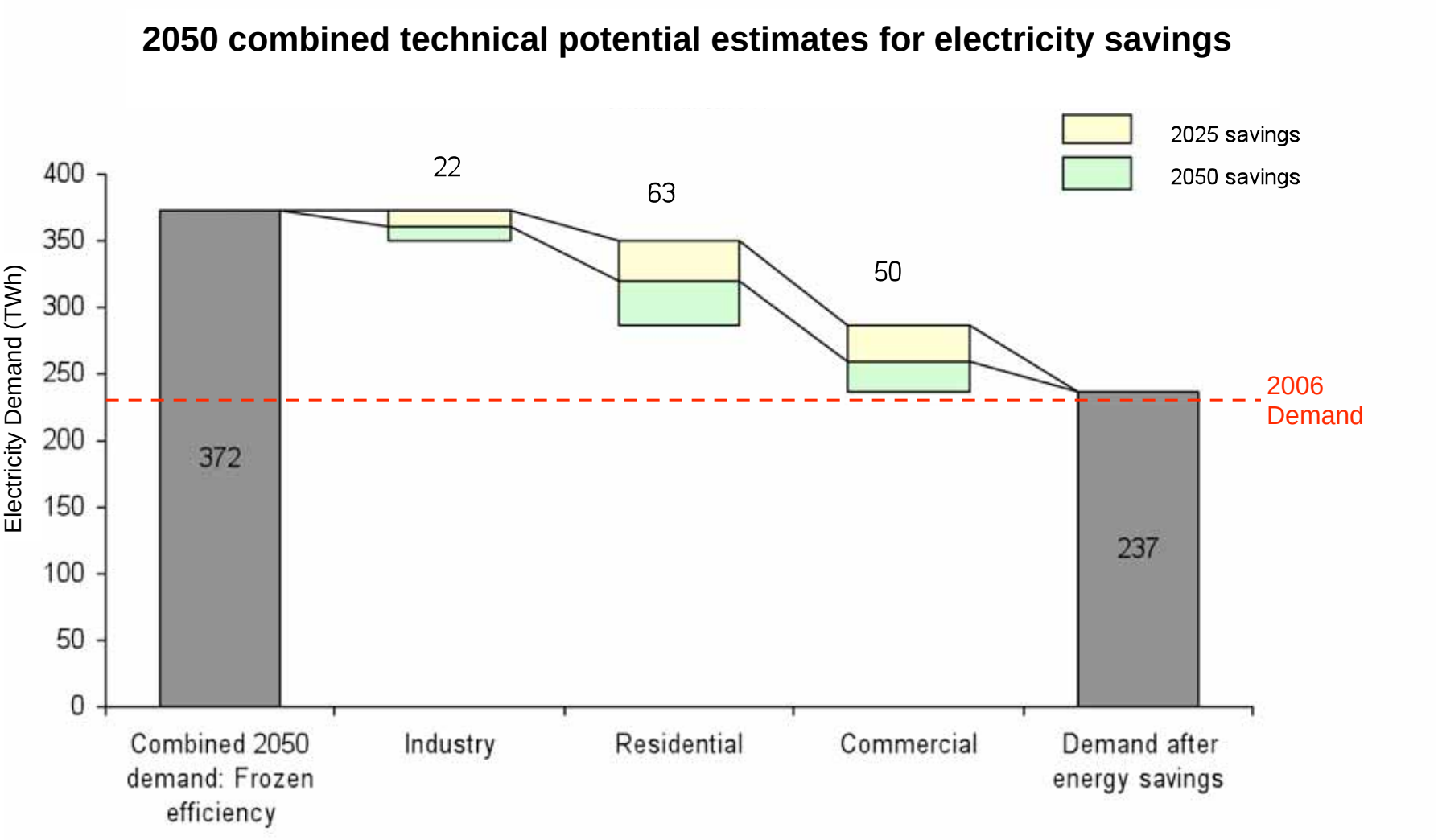
2050 Industrial Electricity Potentials



2050 Industrial Gas Potentials

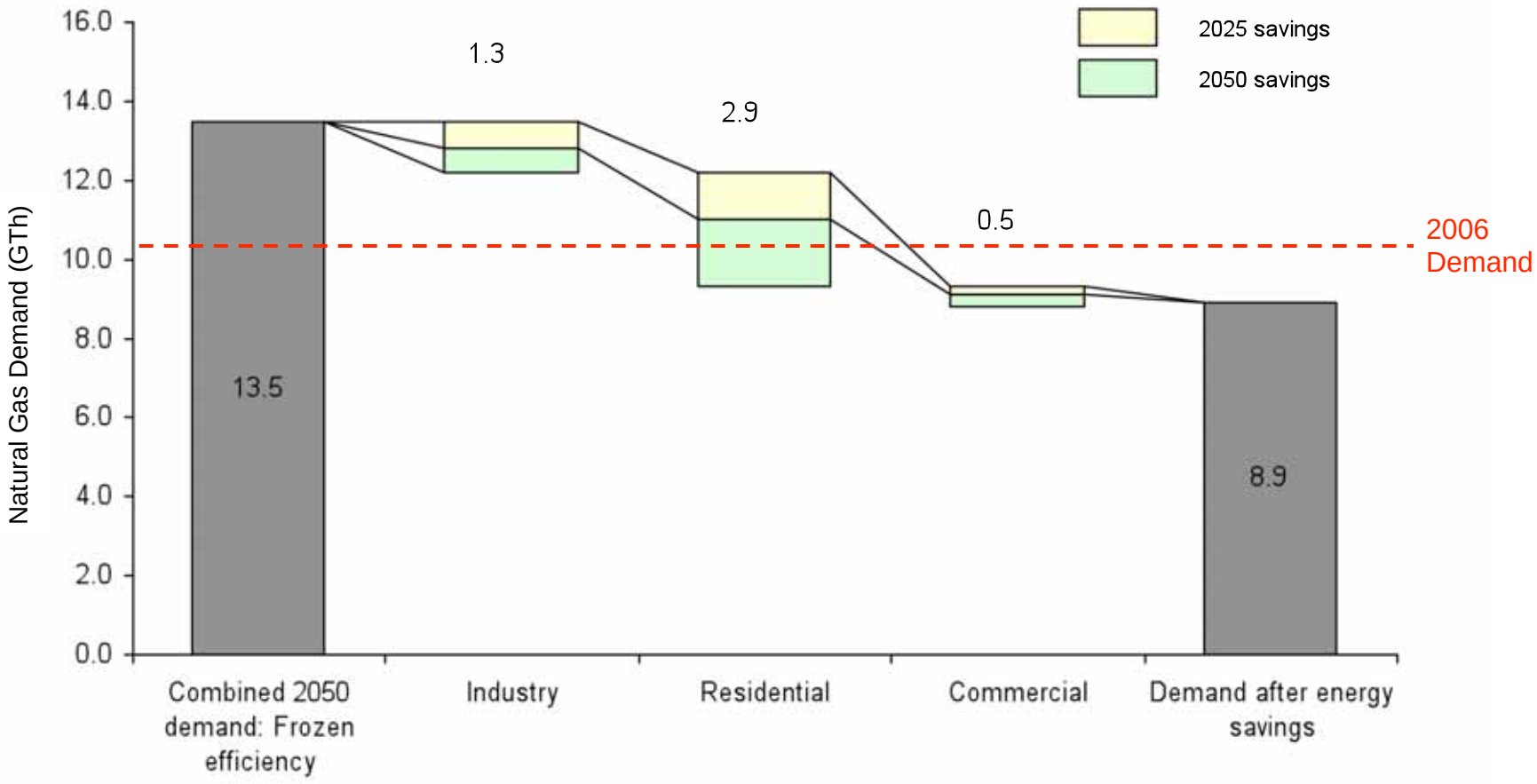


Total technical potential: electricity



Total technical potential: natural gas

2050 combined technical potential estimates for natural gas savings



Uncertainty and sensitivity analyses

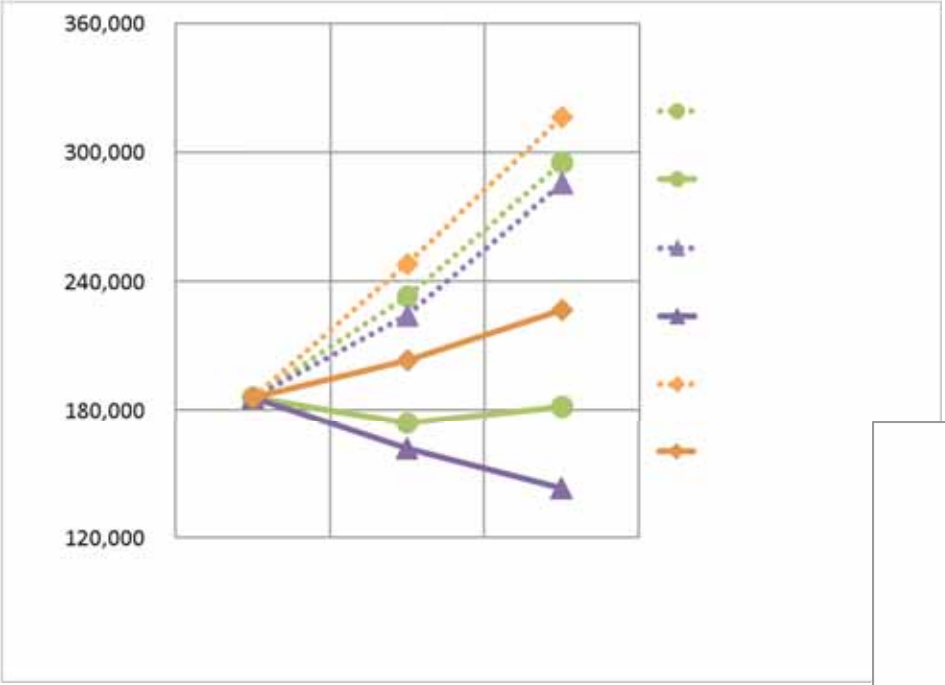
- **Parameter uncertainty: high and low estimates developed for all end-use efficiency estimates and each demand driver**

Average annual growth rates in % in Benchmark, Low growth, and High growth cases, 2006-2050			
	Benchmark	Low	High
Population	1.08	0.96	1.21
Labor force	1.07	0.99	1.29
Labor productivity	1.70	1.50	2.00
GSP	2.80	2.50	3.31
Non-industrial output	2.96	2.63	3.51

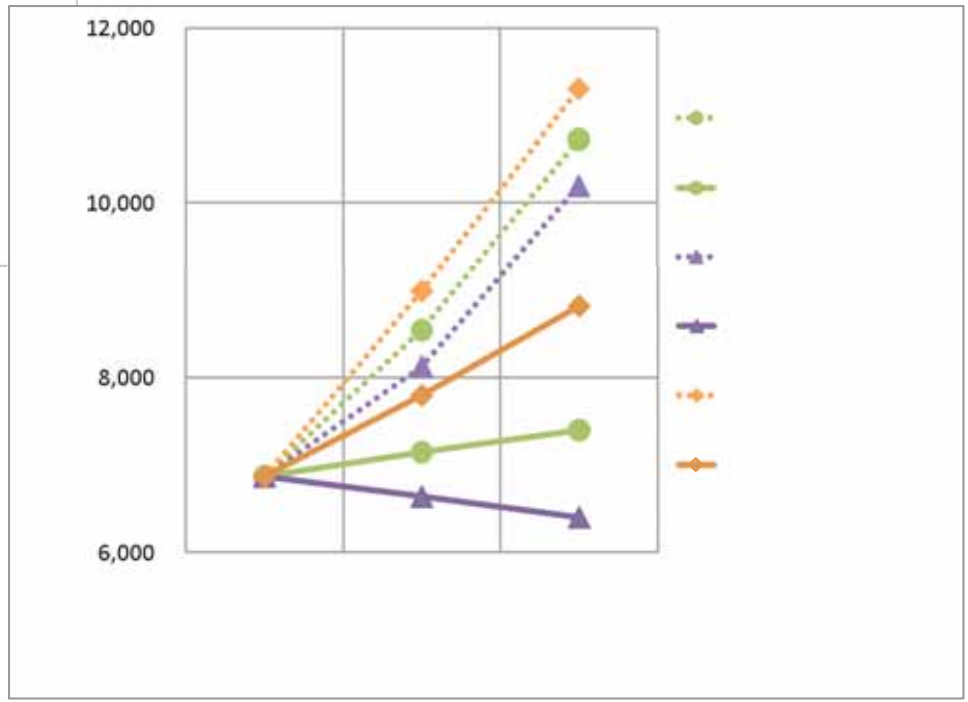
- **Sensitivity: three scenarios developed to explore the robustness of long-term potentials:**

Scenario	Case Assumptions					
	Industrial		Residential		Commercial	
	GSP	Energy Efficiency	Population	Energy Efficiency	Floor Area	Energy Efficiency
Benchmark	Benchmark	Mid	Benchmark	Mid	Benchmark	Mid
High	High	Low	High	Low	High	Low
Low	Low	High	Low	High	Low	High

Sensitivity case results: Buildings

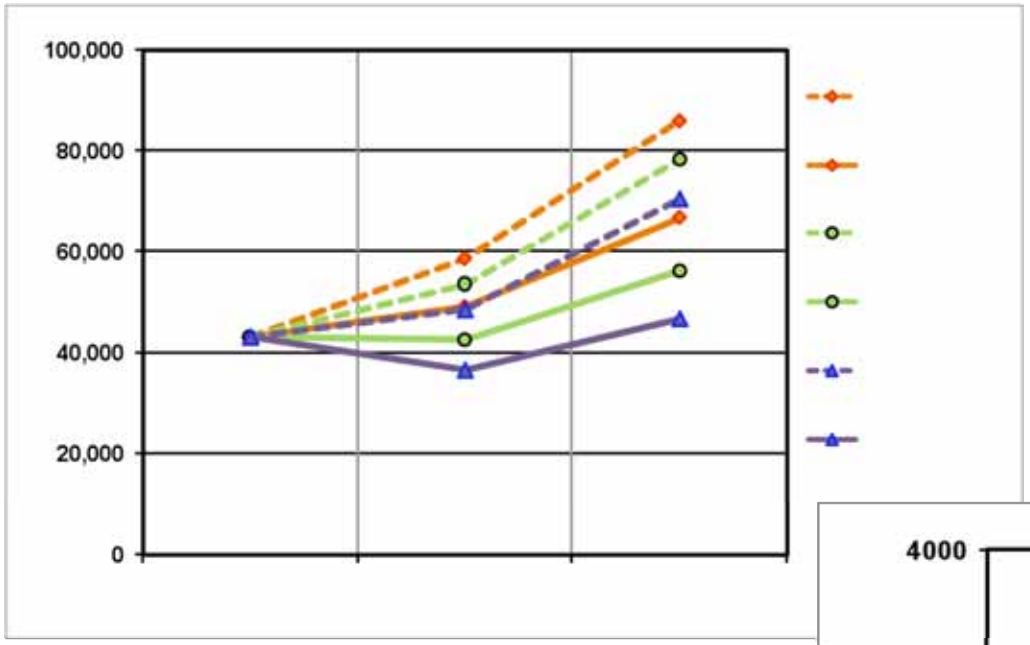


- Projected demand for electricity and natural gas highly sensitive to high-low estimates of technical potential but relatively insensitive to high-low forecasts of population and economic growth



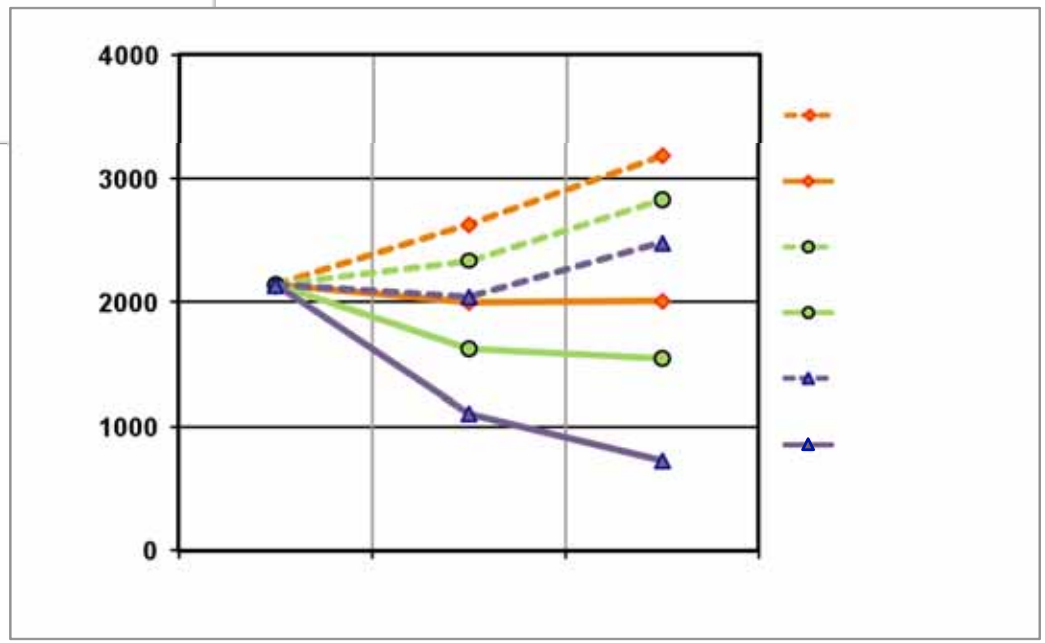
- Aggregate demand in 2050 increases or decreases, depending on level of energy efficiency potential assumed

Sensitivity case results: Industry



- Electricity demand rises in all cases due in part due to high Benchmark Scenario growth in electricity-intensive industries (chemicals, plastics, electronics)

- Natural gas demand levels off or decreases due in part to low Benchmark Scenario growth in gas-intensive industries (petroleum refining, food, metals, glass, and cement)



Conclusions

- **Growth in energy demand drivers for California buildings and industry will significantly increase the challenge of reducing aggregate electricity and natural gas use over the long term**

- **Long-term, technology-focused modeling efforts can help illuminate the greatest opportunities for efficiency improvements in California related to specific technologies, end uses, and building/industry types**

- **Results are highly scenario-dependent. However, the modeling framework can be used to investigate a range of assumptions for changes in state demographics, economic structure, and energy demand to identify robust decisions**

- **This work should help identify critical areas of opportunity, challenges, and knowledge gaps in future planning and modeling efforts toward meeting the state's ambitious energy use and GHG emissions reduction goals**